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Tool for the Generation of Schedules using Genetic Algorithms

Herramienta para la Generación de Horarios empleando Algoritmos Genéticos

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Abstract

In this document the analysis, design and implementation of a system that assigns teachers and classrooms to concentrate schedules using Genetic Algorithms in the career of Information Technology and Communication (ICT) at the Technological University of the Northern Region of Guerrero described (UTRNG) in which there is the need to allocate and coordinate economic, material and human resources for the benefit of students. Each semester start must be organized and distributed class schedules for classrooms and teachers, so this should be taken into account the number of groups formed, which are not the same as they vary each period. One of the complicating factors is the realization that not all teachers have the same availability, having to take into account their free time.

Genetic algorithms, Artificial Intelligence, Assignment schedules

Resumen

El presente documento describe el análisis, diseño e implementación de un sistema que asigna profesores y aulas a un concentrado de horarios utilizando Algoritmos Genéticos en la carrera de Tecnologías de la Información y Comunicación (TIC) de la Universidad Tecnológica de la Región Norte de Guerrero. (UTRNG) en la que es necesario asignar y coordinar los recursos financieros, materiales y humanos en beneficio de los estudiantes. Cada inicio de semestre se deben organizar y distribuir los horarios de clases de las aulas y de los profesores, para ello se debe tomar en cuenta el número de grupos que se forman, los cuales no son los mismos cada periodo ya que varían. Uno de los factores que complica su realización es el hecho de que no todos los profesores tienen la misma disponibilidad, teniendo que tener en cuenta sus horas libres.

Algoritmos Genéticos, Inteligencia Artificial, Programación

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Introduction

The generation of class schedules is one of the most complicated tasks when starting a new school year in all educational institutions, that is, they encounter the problem of allocating and coordinating economic, material and human resources for the benefit of the students. In particular with the organization and distribution of class schedules for teachers and students, because they present particular conditions caused by the growth of the student population.

Today there are different systems for sale developed to generate class schedules, but they are not 100% automated, that is, the user is required to be in charge of assigning the teachers to the groups and the system only indicates if there is a conflict. or the matter is already assigned to another teacher.

In September 2003, the Technological University of the Northern Region of Guerrero (UTRNG) began its first school cycle. Due to not having its own facilities, the "24 de Febrero" Preparatory School for Cooperation in Iguala, Gro., lends its building for the teaching of lessons. The UTRNG offers four university careers to prepare Higher University Technicians (TSU) in: Computer science, currently Information and Communication Technologies (ICT), Mechanics, Production Processes and Textile Production Processes, which are in a period of two years, of In this way, the TSUs can be integrated in a short time into the productive sector that requires specialized technicians in specific areas.

Schedule Definition

A schedule is an organized list, usually in tabular form, providing information about a series of events, here are some definitions:

- Table indicating the hours in which certain acts must be executed. [one]
- Arranged time for certain activities: working hours. [two]
- Indicator table of departure and arrival times: flight schedule. [two]
- Time during which an action or activity is habitually or regularly carried out. [3]
- Table indicating the hours in which certain activities must be carried out. [3]

Distribution of the days and hours in which a service is provided or an activity or work must be carried out. [4]

It is the time from one hour to another determined, during which the worker performs their duties in one of the established work days.

Bookstore Weekly Schedule — Week of : May 1-7

	Sun 5/1	Mon 5/2	Tue 5/3	Wed 5/4	Thu 5/5	Fri 5/6	Sat 5/7
Bourne, M.	9am-6pm	9am-6pm	9am-1pm				
Brown, M.	11am-8pm	11am-8pm	7am-11am		9am-6pm	9am-6pm	
Gatsby, A.		11am-8pm	11am-8pm	7am-11am			
Gordon, A.				11am-8pm	11am-8pm	7am-11am	
Heider, V.							
Lawson, N.		11am-8pm	11am-8pm	7am-11am			
Shiro, I.					9am-6pm	9am-6pm	9am-1pm
Smith, T.	9am-6pm	9am-6pm				9am-6pm	9am-6pm
Talbot, P.						9am-6pm	9am-6pm
Tate, L.				9am-6pm	9am-6pm		
Vasquez, A.	11am-8pm	11am-8pm	7am-11am				

Figure 1 Example of a restaurant schedule

A weekly or monthly schedule is usually in alphabetical order, the employees being listed on the left side of a table, with the days of the week at the top of the table. Figure 1.

A schedule is most often created by a manager. In larger operations, a human resources manager or specialist may be dedicated solely to writing the schedule.

The problem of generating schedules has been attacked in various ways worldwide, such as the International Timetabling Competition, which is organized by the Metaheuristics Network and sponsored by the "Practice and Theory of Automated Timetabling" (PATAT) the International Timetabling Competition , which was open to any applicant. The proposed problem is to create a weekly schedule for a university.

Pproblem statement

The Information and Communication Technologies (ICT) career at the Technological University of the Northern Region of Guerrero (UTRNG) currently has a student population of approximately 1,200 students, each year around 350 to 400 students enter the career. As the intake of students varies, the number of teachers and classrooms increase and as a consequence the schedules are not always the same.

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The preparation of schedules is carried out as follows:

- Before the end of the semester, the career directions ask all the teaching staff for the subjects in which they fit their profile.
- A commission is formed that designates the Race Directorate to prepare the schedules.
- LThe schedules are generated manually, assigning each teacher subjects in front of the group, taking into account table 1:

Teacher Type	hours FRent To group Minimum	hours Frent And to ggroup Maxi mo
Teacher from Weather Full	4	25
Teacher and Subject	3	25

Table 1 Hours against statutory group

- The group that advises a full-time professor will be included in the allocation of hours.
- If any teacher was designated for two subjects to a single group, everything must be reviewed again to determine which subject they will leave.

The distribution of schedules is a reality of every academic institution. It is a process that is carried out, currently manually, as is the case of the Technological University of the Northern Region of Guerrero and specifically in the Information and Communication Technologies Career. This process sometimes becomes cumbersome and at the same time not very expeditious, it is this situation that motivated the development of this Thesis.

All of the above makes the preparation of schedules a time-consuming and heavy task for those who are doing it. Causing classes to normalize one or two weeks after the school year established by the Guerrero Secretary of Education has started.

Hypothesis

Teachers and classrooms can be assigned to a condensate of schedules at the Technological University of the Northern Region of Guerrero with the method of Genetic Algorithms.

General objective

Solve the problem of assigning groups to teachers and groups to classrooms in the Information and Communication Technologies career at the Technological University of the Northern Region of Guerrero with the development of a system using Genetic Algorithms.

Specific objectives

Reduce the time in the elaboration of schedules for teachers, which are carried out in several days.

Eliminate the collisions of masters to already assigned groups and verify to this one that 2 masters are not assigned to the same group.

Improve the assignment of hours, distributing class hours equitably among teachers.

Artificial Intelligence (AI)

Artificial Intelligence is the science that attempts to create programs for machines that mimic human behavior and understanding. Research in the field of AI is characterized by the production of machines for the automation of tasks that require intelligent behavior.

Some examples are in the area of system control, automatic scheduling, the ability to respond to diagnostics and consumer queries, handwriting recognition, speech recognition, and pattern recognition. In this way, it has become a scientific discipline, focused on providing solutions to problems of daily life. AI systems are currently part of the routine in fields such as economics, medicine, engineering and the military, and have been used in a wide variety of software applications, strategy games such as computer chess and other video games [5].

LAI is divided into two schools of thought, conventional Artificial Intelligence and Computational Intelligence.

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Computational Artificial Intelligence

Computational intelligence implies iterative development or learning (eg, iterative modifications of parameters in connectionist systems). The knowledge is achieved based on empiric facts. Some methods of this branch include:

- Neural networks: systems with great pattern recognition capabilities.
- Fuzzy systems: techniques to achieve reasoning under uncertainty. It has been widely used in modern industry and consumer products such as washing machines.
- Evolutionary Computing: Applies biologically inspired concepts such as population, mutation, and survival of the fittest to generate successively better solutions to a problem. These methods in turn are divided into evolutionary algorithms (eg Genetic Algorithms) and collective intelligence (eg ant algorithms)

Genetic Algorithms

The Genetic Algorithms (originally called ―genetic reproductive plans‖) were developed by John H. Holland in the early 1960s [6, 7], motivated by solving machine learning problems.

The genetic algorithm emphasizes the importance of sexual crossover (primary operator) over that of mutation (secondary operator), and uses probabilistic selection. The basic algorithm is as follows:

- Generate (randomly) an initial population.
- Calculate fitness of each individual.
- Select (probabilistically) based on suitability.
- Apply genetic operators (crossover and mutation) to generate the following population.
- Cycle until a certain condition is satisfied.

The traditional representation is binary, as exemplified in Figure 2.

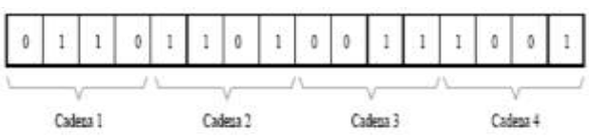

Figure 2 Example of the encoding traditionally used with Genetic Algorithms

To the ACwelcome binary I know you call ―cromosoma‖. Each position in the chain is called a ―gene‖ and the value within this position is called an ―allele‖. In order to apply the genetic algorithm, the following 5 basic components are required:

A representation of potential solutions to the problem.

A way to create an initial population of possible solutions (usually a random process).
An evaluation function that plays the role of the environment, ranking solutions in terms of their "fitness."
Genetic operators that alter the composition of the children that are will produce pairto the next generations.
Values for the different parameters that uses the genetic algorithm (population size, crossover probability, mutation probability, maximum number of generations).

System design

Figure 3 shows the conceptual map of the project. It represents the Genetic Algorithm to generate the schedule, where we can see graphically the most representative components of the processes used.

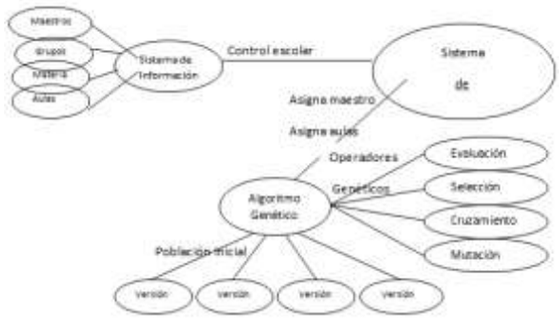

Figure 3 Conceptual map of the Genetic Algorithm Module

In the information system module, school services will provide the necessary information for the administration of schedules in general and provide the data for the operation of the other modules.

The Genetic Algorithm module shows the data that is received, the generation of the initial population, the process that is applied

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through genetic operators and the information that is generated.

Results and System Tests

To check the quality of the software that according to the definition of Roger S. Pressman is "concordance with the established functional and performance requirements, with the explicitly documented development standards and with the implicit characteristics that are expected of all professionally developed software" [8], several tests were carried out that are documented below.

MTeacher assignment module

Objective: Provide the data of the teachers that the module requests, so that later the system has all the necessary information.

Acceptance Criteria: This test must show subject schedules with a teacher assignment without clashes. Test procedure: An assignment of teachers is generated using the procedures of the Genetic Algorithms for several generations until a generation without clashes in the group is achieved.

Test result: The results were satisfactory. In all the cases presented, the system assigned teachers to groups in less time than was used before. This screen (figure 4) is used to add, delete, consult and modify the information of the professors that the university teaching staff has.

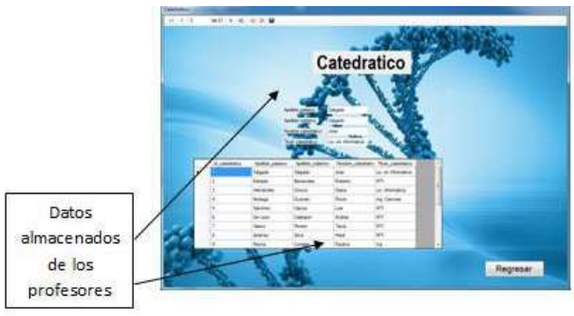

Figure 4 Administra to professors

To start making the schedules, it is necessary to generate an initial population, which is done on the next screen (Figure 5). In which it does not allow a teacher to be assigned to a subject in a group if another teacher is already assigned, as well as prevents a teacher from being assigned more than 6 subjects.

Figure 5 Pscreen generated by the initial population

Once the population was generated, the following consisted in evaluating the generation of the new individuals, for this it was analyzed looking for all the shocks that existed in the hours of each one of the individuals (Figure 6).

Figure 6 Pversion evaluation screen

In the next window (Figure 7), the selection of the versions to keep for the next generation was made, eliminating the versions with the highest number of crashes.

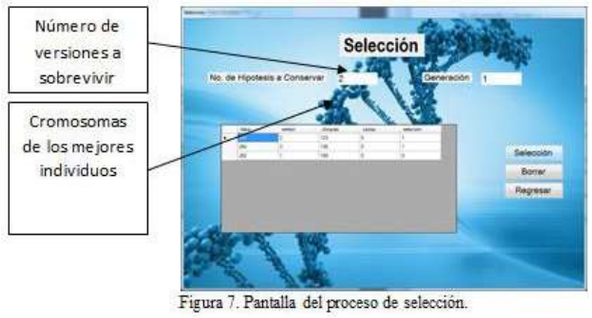

Figura 7. Pantalla del proceso de selección.

Figure 7 Pselection process screen

The remaining versions of the population are used in a new cross to generate a new population with individuals with characteristics different from those that existed (Figure 8).

Figure 8 Pscreening of the crossing process

In some cases it was necessary to alter the genetic content of the information, this was done through mutation, where the information could be modified in such a way that errors were corrected and it would help to find a faster possible solution (Figure 9).

Figure 9 Pscreen of the mutation process

Once the entire process of evaluation, selection, crossing and mutation has been carried out ―n‖ times, what remains are the best versions to use as final schedules. Therefore, the optimal version had to be chosen (Figure 10).

Figure 10 final times

Mclassroom assignment module

Objective: Provide the data that the module requests, so that later the system has all the necessary information.

Acceptance Criteria: This test must show subject schedules with a classroom assignment without clashes.

Test Procedure: Classroom assignment is generated using Genetic Algorithm procedures over several generations until a generation without classroom clashes is achieved.

Test result: The results were satisfactory. In all the cases presented, the system assigned the corresponding classrooms.

This screen (figure 11) was used to add, delete, consult and modify the information of the available Classrooms, so that the Genetic Algorithm would use them during the assignment process.

Figure 11 Classroom administration screen

To begin assigning classrooms, an initial population needed to be generated, which was done on the next screen (Figure 12).

Figure 12 Pscreen that generates the initial population

Once the population was generated, the next thing was to evaluate the generation of the new individuals, for this it was analyzed looking for all the shocks that existed in the hours of each of the individuals (Figure 13).

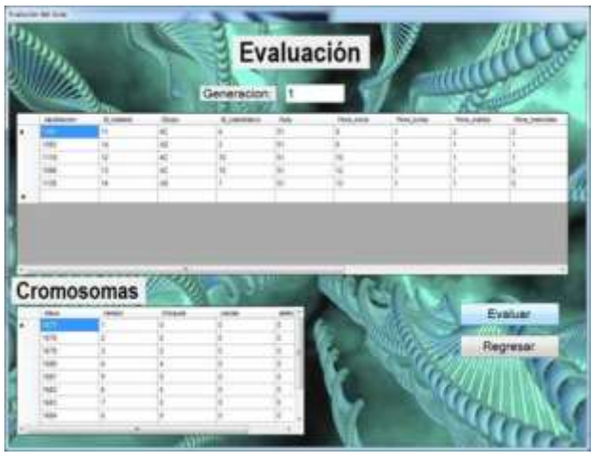

Figure 13 Pversion evaluation screen

In the next window (Figure 7.14) the selection of the versions to keep for the next generation was made, eliminating the versions with the highest number of crashes.

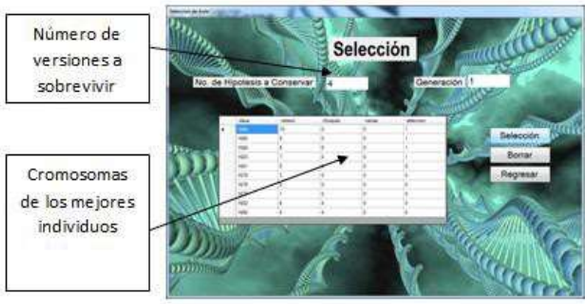

Figure 14 Pselection process screen

TheThe remaining versions of the population were used in a new cross to generate a new version with individuals with characteristics different from those that existed (Figure 15).

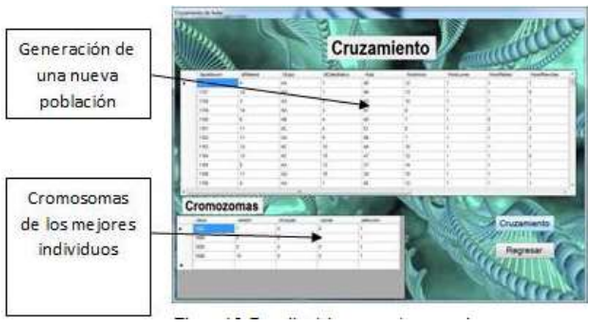

Figure 15 Pscreening of the crossing process

In some cases it was necessary to alter the genetic content of the information, this was done through mutation, where the information was modified in such a way as to correct possible errors and thus find a faster possible solution (Figure 16).

Figure 16 Promutation process

Once the entire process of evaluation, selection, crossing and mutation ―n‖ times what is left are the best versions to use as final schedules. Therefore, the best version of schedules had to be chosen to distribute it (Figure 17).

Figure 17 Condschedules with assigned classrooms

Conclusions

With this project carried out, the assignment of professors and classrooms for the Information and Communication Technologies career at the Technological University of the Northern Region of Guerrero will be carried out more quickly compared to how they were previously done, avoiding loss of time to make them.

The time of several days is reduced to a few minutes in the elaboration of the schedules assigning professors and classrooms.

The assignment of 2 professors to a subject to the same group is avoided, as well as the collisions of professors and classrooms to already assigned groups.

Professors are equally assigned the same number of hours compared to the group.

This demonstrates that using the genetic algorithm method, teachers and classrooms can be assigned to a condensed schedule.

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